HXS Operating Procedures

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1. Instrument Overview

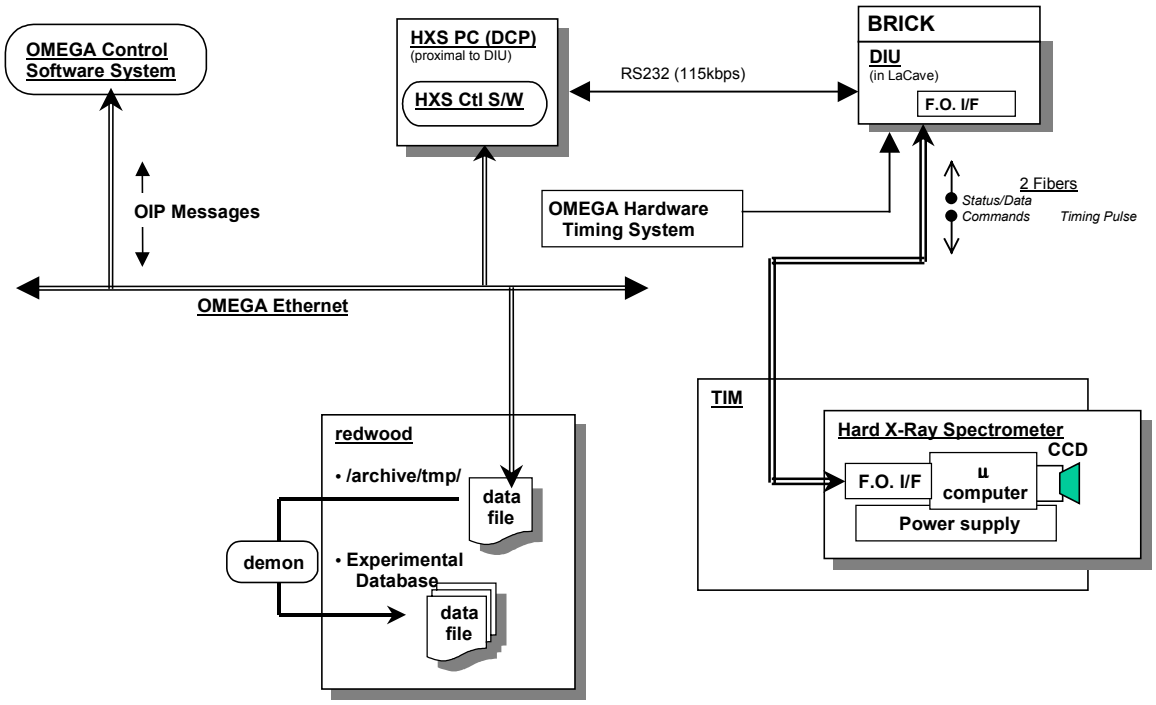
The Hard X-Ray Spectrometer (HXS) diagnostic is an instrument, fielded in a TIM at the OMEGA laser facility, whose purpose is to record the hot-electron Bremsstrahlung energy distribution in the x-ray energy range 12 to 60 keV region (see Figure 1). The spectrometer is an adaptation of a compact and robust instrument that was originally developed at NIST for the energy calibration of medical radiography x-ray sources. The spectrometer is composed of a cylindrically bent crystal, slit, scatter shielding, and a detector plane that is compatible with a CCD camera or a streak camera (see Figure 2). The CCD x-ray detector provided with the instrument is detachable so that an LLE streak camera can be mounted for the purpose of recording time-resolved spectra. Based on preliminary sensitivity tests of a prototype spectrometer and the expected hard x-ray flux from OMEGA targets, well-exposed spectra can be recorded on the CCD on a single laser shot.

The HXS diagnostic is comprised of 5 major sub-systems:
1) Nosecone assembly and cylindrically bent crystal spectrometer body
2) CCD detector module
3) Drive Electronics (DE)
4) Internal Battery Pack (IBP)
5) Diagnostic Interface Unit (DIU)
6) Diagnostic Control Processor (DCP) Laptop PC

<< fig 1: insert picture of the HXS setup in a bench-test configuration >>

<< fig 2: insert mechanical drawing of the instrument >>

The HXS has support hardware in order to interface to the OMEGA data system (see Figure 3). The hardware consists of a Diagnostic Control Processor (DCP) Laptop PC and a Diagnostic Interface Unit (DIU). In addition the Battery Recharge Interface Control Keeper (BRICK) is used to charge the Internal Battery Pack (IBP) when in an offline configuration. The following diagram details how the HXS system interfaces with the OMEGA system.



In general, the OMEGA system controls the instrument by interfacing to the DCP. The DCP will respond with self-test status and data collected from the instrument. The DCP handles all control of the instrument via the DIU using the HXS control protocol (which is out of the scope of this document). This control is effected via the data fiber optic link. The DCP will instruct the instrument to prepare for the shot, perform self-tests, set control parameters, and request data. The triggering of the CCD integration cycle is keyed from the LLE timing pulse received on the BNC connector at T-10 seconds. The instrument will generate timing signals at T-delta to begin CCD integration and T+epsilon to terminate CCD integration. Delta and Epsilon are configurable parameters. The instrument data will be sent to the OMEGA system in a TBD format.

2. Operation Overview

- See the **Static Test Plan** document for bench testing
- Software Revision levels will be reported in Self-Test data
- Communication with the instrument must occur at least every 11.5 hours. If more than 12 hours passes the instrument will enter a shutdown mode, which requires the 25pin S-Sub IBP connector to be removed and reinstalled to resume operation
- Instrument enters the ready state on command from OMEGA and automatically goes into the dormant state when data transfer is complete
- If needed the DCP contains a Graphical User Interface (GUI) control program which can be used to control the instrument in case of communication failure with OMEGA or the instrument is used off line

- Full instrument shutdown is accomplished by disconnecting the 25pin D-Sub connector from the IBP and shutting down the DCP and DIU

2.1. Critical Data

Item	Interface	HXS Supplied Interface Connection/Parameters
Diagnostic Control Computer (DCP)		
	Power	Standard 110VAC
	Network	10Base-T
	Serial	RS-232 via 9Pin female D-Sub 115.2 kbps HXS control protocol
Diagnostic Interface Unit (DIU)		
	Power	Standard 110VAC
	Timing Trigger	Female BNC – 50 Ohm Line Impedance 250ns high-going pulse at T-10
	Serial	RS-232 via 9Pin D-Sub 115.2 kbps HXS control protocol
	Data Fiber	SMA – 400 micron ACS102A Optical Modem protocol
	Timing Fiber	SMA – 400 micron tbd protocol
Battery Recharge Interface Control Keeper (BRICK)		
	Power	Standard 110VAC (combined with DIU power)
	Internal Battery Pack (IBP) Connection	25Pin D-Sub
Drive Electronics (DE)		
	Power	25pin D-Sub from IBP
	Trigger	LLE OTIS F/A SMA
	Data	LLE Fiducial F/A SMA

3. Detailed Procedures:

3.1. Pre-Installation Checks

Intent:
This procedure is to be used prior to installing the HXS instrument. A copy of the attached checklist shall be filled in as the procedure is executed and provided to the ESO when the process is complete.

Prerequisites:
The HXS instrument is to be entered into general operations.

Procedure: (Perform steps in the order listed.)

1) Open the HXS instrument shipping container ❑

   << insert picture of the open shipping container (full with subtitles) >>

2) Verify that the DCP laptop carrying case is present ❑

3) Verify that the DIU/BRICK box is present ❑

4) Verify that the DIU/BRICK AC/DC Adapter is present ❑

5) Verify that the HXS instrument assembly is present ❑

6) Remove the items and perform a bench-test per the **Static Test Plan** ❑

Date/Time _____

Operator _____

3.2. Installation

Intent:
This procedure is to be used in order to install the HXS instrument into a TIM in the target bay. A copy of the attached checklist shall be filled in as the procedure is executed and provided to the ESO when the process is complete.

Prerequisites:
The Pre-Installation procedure must be completed.

Procedure: (Perform steps in the order listed.)

1) Setup the DIU/BRICK ❑

   1. The DIU/BRICK is installed in "La Cave" ?? somewhere ??
   2. Plug the DIU/BRICK AC/DC converter into the rear of the box
   3. Plug the DIU/BRICK AC/DC converter into a powered 110VAC outlet
   4. Connect the LLE T-10 diagnostic BNC Timing cable to the DIU

   << show picture of DIU/Laptop setup together>>

2) Setup the DCP laptop ❑

   1. Place the laptop on top of the DIU/BRICK
   2. Plug the DCP Laptop AC/DC converter into the laptop
   3. Plug the DCP Laptop AC/DC converter into a powered 110VAC outlet
   4. Connect a 10Base-T cable to the ethernet interface on the laptop
   5. Connect the 10Base-T cable to the LLE ethernet (wall or hub)

3) Connect the 9Pin RS-232 cable to the Laptop and the DIU ❑

   - The male end of the cable plugs into the laptop
   - The female end of the cable plugs into the DIU

   << show a picture of the installed cable>>

4) Power up the DIU/BRICK. Verify the Power indicator is illuminated and that self-test completes. ❑

   - Move the power switch located on the front right of the box to the "On" position
   - The power indicator is immediately next to the power switch
   - The self-test will cause the LEDs on the front panel to blink in a sequential pattern. If the test fails, the LEDs will blink on and off in unison.

   << show a picture of the normal DIU/BRICK powered configuration>>

5) Connect the Internal Battery Pack to the 25pin D-Sub connector on the DIU/BRICK. Verify that the charging indicator is illuminated ❑

- The 25pin connector is on the back of the DIU/BRICK
- The charging indicator is on the front-right of the DIU/BRICK
- The charging indicator may take several seconds to illuminate

6) Charge the IBP connected to the DIU/BRICK until the charge LED indicator light begins to blink, indicating the IBP is fully charged. This may take as long as 12 hours if the IBP was fully drained. ❑

Start Date/Time _____ End Date/Time _____

7) Install the assembled HXS instrument into the TIM boat. Do not install the battery pack. ❑

The assembled spectrometer and TIM Interface Plate (TIP) attaches to the TIM boat with tooling balls and spring loaded captive 10-32 PEM hardware.

There are two lifting handles on the DE which are used to lift the TIP into the TIM boat.

8) Install the IBP ❑

The Internal Battery Pack weighs ~ 45 LBS and has two handles which are used to lift it into the rear of the TIM boat. Care must be taken to not damage the water cooling lines or the fiber optic cables when inserting the IBP.

9) Connect the 25Pin D-Sub connector between the DC and the IBP ❑

10 Install the vacuum-side Data Fiber-Optic between the TIM boat connector block assembly and the DE F/O Data Port ❑

- The TIP SMA fiber optic connectors are located on the topside of the Drive Electronics (DE).
- The LLE Fiducial F/O SMA functions as the HXS data fiber optic.
- The cable is routed through the opening in the handles of the DE

<< insert picture of mated data connector with trigger connector open >>

11 Install the vacuum-side Trigger Fiber-Optic between the TIM boat connector block assembly and the DE F/O Trigger Port ❑

- The TIP SMA fiber optic connectors are located on the topside of the Drive Electronics (DE).
- The LLE OTIS F/O SMA functions as the HXS trigger fiber optic.
- The cable is routed through the opening in the handles of the DE

<< insert picture of the mated trigger connector w/ relation to data >>

12 Insert the mating Parker dry connectors from the TIP structure ❑

- The tubes are routed through the opening in the front handle of the IBP

<< insert picture of the mated Parker connectors >>

13 Connect the atmosphere-side SMA fiber optic Jack cables to the DIU ❑

- The LLE OTIS F/O SMA functions as the trigger fiber optic
- The LLE Fiducial F/O SMA functions as the HXS data fiber optic

<< show a picture of connectors mated>>

14 Turn on the DCP laptop PC (located in LaCave) ❑

Wait for Windows98 to boot-up. This may take several minutes.

15 Double-click on the "DCP Omega Interface" icon in the middle of the desktop ❑

- The DCP program will start. This may take a few minutes.
- When the program is ready, it will display a status message saying that the system is okay (in a dialog box). Record the software version number displayed in the dialog box

Software Version _____

Click "Okay" to dismiss the dialog box.

16 Conduct the LLE DAS system test of the HXS instrument. ❑

17 Conduct the CCD aliveness test as discussed in the HXS Static Test Plan document. Proceed if the test image is acquired. ❑

18 Verify that all cables are safely routed inside the TIM space envelope and that the 37 pin D-sub connector RF cover is installed. ❑

19 Install diagnostic Alignment Pointer and deploy for alignment on Omega ❑

20 Remove diagnostic pointer and install Pointer Shield to protect the nose cone seat for the pointer. ❑

21 Notify the ESO that the HXS in TIM __ is ready for insertion. ❑

Date/Time _____

Operator _____

3.3. Operation

Intent:
This procedure is to be used in order to operate the HXS instrument. A copy of the attached checklist shall be filled in as the procedure is executed and provided to the ESO when the process is complete.

Prerequisites:
The HXS Installation procedure must be completed.

Procedure: (Perform steps in the order listed.)

1) OMEGA setup of the instrument ❑

   1. PRESHOT is sent to the DCP
   2. The DCP responds with WORKING
   3. The DCP wakes up the diagnostic and performs an extensive system self-test. (*contents are tbd*)
   4. If self-test is successful DCP reports READY4CHARGE
   5. On failure an ERROR is reported. Extensive information about the failure is sent to the log file, in addition to the ERROR response. Possible error messages are:
      a) ERROR comm_failure - The communication link between the DCP and the instrument is not functioning. *This could be a result of the instrument hibernating due to lack of timely communication.*
      b) ERROR trig_failure - The trigger fiber-optic link is not functioning.
      c) ERROR ccd_failure - The ccd failed to read out an acceptable test pattern.
      d) ERROR battery_fault – The IBP is not capable of completing the shot. Either it is nearing a discharged state or there is a battery malfunction.
      e) ...more tbd...
   6. The DCP puts the instrument back into a low-power mode.

2) OMEGA begins to charge ❑

1. OMEGA issues the CHARGE command
2. The DCP responds with WORKING
3. The DCP wakes up the diagnostic and performs a short self-test, consisting of memory and interface checks. In addition, the timing parameters (delay from T-10, integration time, etc) are downloaded into the instrument.
4. If self-test is successful DCP responds with READY
7. On self-test failure an ERROR is reported. Extensive information about the failure is sent to the log file, in addition to the ERROR response. Possible error messages are:
    a) ERROR comm_failure - The communication link between the DCP and the instrument is not functioning. *This could be a result of the instrument hibernating due to lack of timely communication.*
    b) ERROR trig_failure - The trigger fiber-optic link is not functioning.
    c) ERROR battery_fault – The IBP is not capable of completing the shot. Either it is nearing a discharged state or there is a battery malfunction.
    d) ...more tbd...
5. The DCP maintains the instrument in a wakened state in preparation for the shot. If more than (TBD – say 60 minutes) passes without receiving a T10_ENABLE message, the shot is considered to have been aborted. Messages are logged and the instrument is put back to sleep.

3) OMEGA prepares to proceed with the shot ❑

1. OMEGA issues a T10_ENABLE
2. The DCP responds with WORKING
3. The DCP informs the instrument to prepare for the shot. Any T-10 pulses on the timing fiber-optic will now be considered to be an indication of impending shot.
4. When the instrument is fully prepared for the shot, the DCP will respond to OMEGA with READY.
5. If the instrument cannot proceed with the shot an ERROR response is sent to OMEGA. Possible error messages are:
    a) ERROR comm_failure - The communication link between the DCP and the instrument is not functioning. *This could be a result of the instrument hibernating due to lack of timely communication.*
    b) ERROR trig_failure - The trigger fiber-optic link is not functioning.
    c) ERROR battery_fault – The IBP is not capable of completing the shot. Either it is nearing a discharged state or there is a battery malfunction.
6. The instrument awaits the T-10 timing pulse from the DIU. If the pulse does not arrive within five minutes, the instrument assumes an error or an aborted shot. Error messages are logged and the instrument goes back to sleep.

4) OMEGA warns of impending shot ❑

1. OMEGA send T-10 TTL pulse via coax cable to the DIU.
2. The DIU forwards the pulse to the instrument with a fixed delay of tbd microseconds until reception.
3. Upon receipt of the T-10 pulse, the instrument starts a count-down until the start of CCD integration. At approximately T-4 ABORTS are ignored. At approximately T-3 the CCD will begin clearing the stored charge.
4. At T-delta the CCD will be commanded to begin integration. The instrument will start a count-down timer until the end of integration.
5. When integration is complete, the instrument will read the CCD data and store the complete image in static RAM.

5) OMEGA indicates data collection ❑

1. OMEGA send POSTSHOT command
2. The DCP begins to collect the data from the instrument. When all data is collected, including the various telemetry data from the shot, the instrument is put to sleep.
3. The DCP will perform any needed post-processing of the data (possibly to include trimming the image for storage) The image will be stored on the data server, along with the relevant telemetry data.
4. If the IBP data shows the battery is getting low, the DCP will issue a WARNING response indicating a low battery condition. Otherwise, the DCP will issue DONE.

6) OMEGA system stands-down ❑

1. OMEGA issues a STANDDOWN command
2. No DCP action is required. DCP responds with READY.

7) OMEGA system aborts prior to T-4 ❑

1. OMEGA issues an ABORTING command
2. The DCP responds with WORKING.
3. The DCP informs the instrument of the condition. The instrument reports telemetry and goes to sleep.
4. The DCP reports DONE unless the IBP indicates a low battery condition, in which case a WARNING low_battery is sent.

8) OMEGA system aborts after T-4 ❑

1. OMEGA issues ABORTING
2. The DCP responds with WORKING.
3. The instrument counts down until the T-0 time, completes the integration, and retrieves the image.
4. The DCP collects telemetry from the instrument and puts it to sleep. The image information is *discarded*.
5. The DCP logs the telemetry and various status information.
6. The DCP reports DONE unless the IBP indicates a low battery condition, in which case a WARNING low_battery is sent.

3.4. Removal and Storage

Intent:
This procedure is to be used to shutdown, remove, and store the HXS diagnostic for a significant duration. A copy of the attached checklist shall be filled in as the procedure is executed and provided to the ESO when the process is complete.

Prerequisites:
The HXS instrument is to be removed from general operations.

Procedure: (Perform steps in the order listed.)

1) Exit the DCP OMEGA interface program ❑

   In the lower right corner of the interface program's main screen is a button marked 'Quit'. Click on this button. Click the 'Yes' button when prompted for confirmation.

2) Shutdown the DCP ❑

   1. Shutdown the Windows PC via the shutdown feature located under the start menu. The laptop will power itself off.
   2. Unplug the DCP AC/DC converter three-prong power connector from the wall outlet.
   3. Unplug the DCP AC/DC converter from the laptop
   4. Unplug the DCP 10Base-T connector from the laptop and from the wall
   5. Unplug the 9Pin RS-232 cable from the DCP laptop

3) Put the DCP laptop, the 10Base-T cable, and the AC/DC converter into the laptop carrying case. ❑

4) Shutdown the DIU/BRICK ❑

   1. On the front left of the DIU/BRICK is a power switch. Move the switch to the 'Off' position.
   2. Unplug the DIU/BRICK AC/DC converter three-prong power connector from the wall outlet
   3. Unplug the DIU/BRICK AC/DC converter from the DIU/BRICK chassis
   4. Unplug the 9Pin RS-232 cable from the DIU
   5. Unplug the Trigger and Data fiber optic cables from the DIU
   6. Unplug the BNC timing cable from the DIU

5) Place the DIU/BRICK, the DIU/BRICK power adapter and cables, and the laptop carrying case into the HXS instrument shipping case ❑

   << insert picture of the items in the shipping case >>

6) Retract the HXS instrument and open the TIM cover ❑

7) Dismantle the installed instrument. ❑

   1. Disconnect the IBP 25pin connector from the DE
   2. Disconnect the two vacuum-side SMA fiber optic Jack cables
   3. Install dust covers on the two atmosphere-side SMA fiber optic Jack connectors
   4. Disconnect the mating Parker dry connectors from the TIP structure

8) Remove the DE and Spectrometer assembly from the TIM and place it in the shipping container. ❑

   The assembled spectrometer and TIM Interface Plate (TIP) attaches to the TIM boat with tooling balls and spring loaded captive 10-32 PEM hardware.

   << insert picture of instrument in the shipping container >>

9) Remove the IBP from the TIM boat and install into shipping container ❑

10 Fasten down all Captive 10-32 hardware, close and latch the shipping container ❑

11 Deliver the unit to storage or shipping and record the disposition on the checklist before filing ❑

Date/Time _____

Operator _____